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NEW RESEARCHES ON CONDITIONED REFLEXES[1]

I HAVE the pleasure and the honor to present to the representatives of American science the results of my investigations. For the last twenty years I have studied the highest nervous activities of the dog, the functions of the cerebral hemispheres of the brain. These functions I have studied only physiologically on strictly physiological grounds. I never use any psychological conceptions or terms.

The basis of nervous activity is formed by so-called reflexes or instincts. The instincts are also reflexes, but more complex. The instincts—inborn associations with definite stimulators—correspond to the activities of the organism. On this basis are built the highest nervous activities.

If the action of any indifferent agent coincides in time with the action of an instinct, and if the action of the agent is repeated many times, then this agent, formerly indifferent, begins to stimulate the instinct. Here is an example:

Food stimulates the food reaction, which consists of some movements of the animal and secretion. If some indifferent agent, which previously had nothing in common with feeding, is repeated many times with the feeding of the dog, after a time it begins to stimulate the food reaction when used alone. If we produce some distinct musical sound, for instance, at a given rate of frequency of vibration per second—and always at the same time feed the dog, after a while this sound, used alone, will produce the same food reaction as the food itself.

Such stimulators may be formed from any agent of the outer world and with any other instinct. For example, the self-protective instinct, the sexual instinct, and so on, have both the individual reflexes and the social reflexes. In this way, besides the reflexes or instincts which are inborn, there are some reflexes acquired during the life of the individual. The first, or inborn, reflexes we call unconditioned reflexes and the second, or acquired, reflexes we call conditioned.

It is clear that the conditioned reflexes play a very important part in our behavior, as they are being acquired all during the life of the individual and are the education and the development of the individual.

[1] Address given at Battle Creek Sanitarium, July 7, 1923. Translation furnished by Professor W. N. Boldyreff, Pawlow Physiological Institute, Battle Creek Sanitarium.

These conditioned stimulators serve as signals separate from the unconditioned stimulators and, like any other signals, they may not signalize properly. Then they ought always to be corrected.

For instance, in the experiments mentioned the sound produced by one thousand vibrations per second was made a conditioned stimulator. If the sound is repeated without the simultaneous feeding of the dog, then for some time the sound loses its stimulating action. But this does not destroy the conditioned reflexes. Sometimes the stimulating action returns again. Here is another example: If the conditioned stimulator is combined with another agent—any other agent—and is not at the same time combined with feeding, then in this combination the conditioned reflex loses its stimulating action.

In both these cases we deal with inhibition. In this way the process of inhibition always accompanies the activity of the highest nervous centers. The process of inhibition exists for another end. It helps to differentiate the various stimulations from the outer world. For instance, let us form from the sound caused by one thousand vibrations per second a conditioned stimulator for the food reaction, which means this sound always produces the ordinary food reaction or the secretion of saliva. After this secretion reaction was formed to this particular sound all the sounds of the neighboring frequencies, say, 960 vibrations or 1,100 vibrations, also produced the same effect; that is, all the sounds of nearly the same frequency acted as stimulators for food reaction. Yet it is possible to reach a high grade of differentiation. If we always produce only sounds caused by one thousand vibrations with the feeding of the dog, carefully excluding all the other sounds, after a time all the other sounds will lose their stimulating action and only the one sound, that caused by one thousand vibrations per second, will act as a stimulator for the food reaction. In this way, the limit of the differentiating ability of the dog or of any other animal may be very easily found. It was shown that the dog very easily differentiates 110 beats per second of the metronome from 100 beats per second, sometimes after intervals of one to three days between experiments.

In this way conditioned reflexes and analysis make up the whole activity of the nervous system. It is interesting to point out that recently we have proved that the process of inhibition which plays a part in the nervous activity of the animal is exactly the same process as that of sleep. It may be stated as follows: The differentiating inhibition in sleep is divided into small parts, and sleep is the diffused continuous inhibition. In this way there is no marked contrast between the normal, active state and the sleepy state. Here are some proofs.

All cases of inhibition may produce sleep unless some special precautions are taken. The differentiation of sleep just mentioned, the special measure which prevents the inhibition from causing sleep, is indeed the existence of stimulating points in the cerebral hemispheres of the brain. The process of stimulation interferes with the process of inhibition and reduces it to a limited space. In some experiments we have seen how slowly the process of inhibition spreads over the cerebral hemispheres. The speed of the movement of inhibition is measured not only in seconds but sometimes in minutes. The process of stimulation irradiates much more qiuckly.

From this point of view some of the phenomena of hypnosis may be understood. Hypnosis is the very slow-spreading process of inhibition. To illustrate this, the following experiment on the dog may be described. We can produce some inhibition in one of the experiments which were mentioned. If we do not interfere with this process of inhibition through the radiation of stimulation, then after some time the process of inhibition is converted into sleep; and the sleep may be stopped in the following interesting stage or phase. We use the conditioned food stimulator. The dog responds to it with the secretion of saliva, but when we offer him food he does not take it. The food reaction, the saliva reaction, shows first that some part of the cerebral hemispheres is active; and, second, the fact that he does not take the food shows that the motor part of the hemispheres is inhibited. We have here a complete analogy to a known state of hypnosis. When in a certain definite state or phase of hypnosis, the hypnotized man understands perfectly well what he is told and even remembers it afterwards, but is not able to produce any movement. That is absolutely analogous to the previous case; but only the motor part of the cerebral hemispheres is inhibited in the last example. In this way these experiments illustrate not only the active state of the cerebral hemispheres but also the sleeping state.

The latest experiments (which are not yet finished) show that the conditioned reflexes, *i.e.*, the highest nervous activity, are inherited. At present some experiments on white mice have been completed. Conditioned reflexes to electric bells are formed, so that the animals are trained to run to their feeding place on the ringing of the bell. The following results have been obtained:

The first generation of white mice required 300 lessons. Three hundred times was it necessary to combine the feeding of the mice with the ringing of the bell in order to accustom them to run to the feeding place on hearing the bell ring. The second generation required, for the same result, only 100 lessons. The third generation learned to do it after 30 lessons.

The fourth generation required only 10 lessons. The last generation which I saw before leaving Petrograd learned the lesson after 5 repetitions. The sixth generation will be tested after my return. I think it very probable that after some time a new generation of mice will run to the feeding place on hearing the bell with no previous lesson.

It is well known that a chicken when it just comes from the egg immediately begins to pick up any black spot on the floor, trying to find some grain, thus showing that it has an inborn reflex from the eye to the food reaction. Why should we not build up the same reaction, not from the eye but from the ear as indicated in the case of the white mice?

The experiments in this direction with sound show very great progress. We obtained a great many results in a very short time. Similar experiments were made on men, with analogous results. We do not see any future difficulties, and at the same time the subject is of very great importance.

My firm belief is that the best way to a knowledge of the mechanism and the laws of our subjective world lies in the direction of the pure physiology of the hemispheres. In this way, in trying to estimate the influence of physiology in human life, we often acquire an unexpectedly large view.

All the rules for education and development ought to be taken from physiology. This opinion I have endeavored to support in this lecture by a short description of some of my experiments.

I. P. PAWLOW
PETROGRAD, RUSSIA

ON THE FUNCTION OF THE CEREBELLUM

IT is now ninety-nine years since Magendie taught that the function of the cerebellum is to regulate our bodily equilibrium. Flourens (1842) emphasized the fact that it helps to bring our complicated muscle-action into harmonious relation and that cerebellar symptoms are purely motor and not based upon any form of sensory disturbance; Lussana regarded it as the central organ of muscle-sense. Until that time these authors had confined their studies to the well-ordered higher work of the cerebellum; later it was analyzed with regard to elementary function.

After twenty years' experiments (1884–1904) Luciani found, after removal of the cerebellum, three important functions missing, the loss of which he designated as atonia, asthenia and astasia. Directly after extirpation of the cerebellum there appear hypertonia of the muscle in the form of opisthotonus, and later hypotonia or atonia, or, in the inclusive terminology of Lewandowsky, cerebellar dystonia. This leads to dysmetria and by oscillation and jerkiness of the body to astasia.

In the opinion of Babinski, atonia is an unimportant symptom, a simple matter of muscle softness, and asthenia is not a true weakness, but simply the result of the violence of distorted movements. André-Thomas, who has combined experimental and clinical researches, regards atonia as of rare occurrence and asthenia as not cerebellar in origin.

Gordon Holmes, who has studied the cerebellar symptom-complex of the acute lesions produced by gunshot wound, agrees with Luciani that atonia, asthenia and astasia are fundamental defects of functions in cerebellar lesions, but he interprets them somewhat differently from Luciani. Babinski proposed to give the designation "adiadochokinesis" to the loss of the faculty of voluntarily executing rapidly alternating movements when the simple component movements are carried out with normal celerity. Holmes defined atonia as the diminution of that slight constant active tension which is characteristic of normal muscle, and regards it as a factor in the production of Babinski's adiadochokinesis. Luciani applies the term "dysmetria" to the violent and disordered movements in walking, involving excessive expenditure of energy, which are noticeable in a dog without cerebellum. He explains it as the premature relaxation of the extensors during the flexion phase of the step, and conversely premature relaxation of the flexors during the extension phase, so that the foot is lifted too high, or planted on the ground with a stamp. In Holmes's theory it depends upon a faulty combination of muscular contractions and is due to delayed muscular relaxation or ill-proportioned range and force of movement. Babinski calls it *gaspillage d'énergie* or waste of energy, assuming that the arresting action of the cerebellum upon muscular contractions is destroyed by extirpation or disease.

In the complex combination or sequence of several simultaneous movements, there is another disturbance which we call "asynergia." According to Holmes, it is the absence or disturbance of that proper synergic association in the contraction of muscles which assures that the different components of an act follow in proper sequence, at the proper moment, and are of the proper degree, so that the act is executed accurately and with the least possible expenditure of energy. In his opinion adiadochokinesis depends upon atonia, asynergia, dysmetria and delayed contraction and relaxation of muscles, while André-Thomas regards it simply as a natural result of dysmetria.

The opinions of these different authors are so far asunder that, as Walshe has said in his summary of the reports, "the hypotheses are couched in such vague and general terms as to be little more than restatements of an unsolved problem, while the analyses are diverse and do not reach the fundamental

factors of cerebellar ataxy." Nevertheless, we regard adiadochokinesis, dysmetria, asynergia and ataxia as important symptoms in the diagnosis of cerebellar affections, and they render good clinical service. Of course we shall not cease to seek better signs to enable us to perceive the functions and pathology of the cerebellum.

The localization of function is less well known in the cerebellum than in the cerebrum. What Bolk supposed on the ground of comparative-anatomical study, and what Rynbork, Rothmann and others made probable by experiments on animals was proved in the human cerebellum by Barany's physiological and clinical research, that there are areas of the cerebellar cortex which correspond to the extremities. In the first place, the muscles of the extremities are represented in the cerebellum by directions of movements, that is to say, there exist four centers, those for right, left, upward and downward. In the case of rest there goes from the four centers to the muscles of the extremities a tonising impulse; and thus equilibrium is maintained. If, for example, the left center is suddenly destroyed, the right extremity moves vertically to the right side, because the left center having disappeared, the right becomes overweighted. If the upper center is destroyed the extremity moves in a horizontal direction in analogous manner downward. The centers for all these movements are localized on the cerebellar hemispheres in the *lobus semilunaris superior et inferior* and in the *lobus biventralis*. Only the site of the center for upward movements of the arm is unknown. The action of these centers is like that of two bridles, the relaxation of one causing the overweight of the other.

If we now examine the cerebella of fish, we find that the apparatus for maintaining equilibrium of the body in the amphioxus, cyclostome and plagiostome is not yet well developed. The Teleostei have, in the medulla oblongata, large cells called Mauthner's cells, which have the function of maintaining equilibrium. Moreover, in this class of fish the "back-cerebrum" is also well developed, corresponding to the cerebella of other animals. We see further that the cerebellum is almost absent in a variety of skate which stays at the bottom of the sea practically motionless, while in the common variety which swims, it is well marked. It is also very interesting to see that the cerebella of fish have several different, sometimes very curious, shapes: standing up straight or lying down forward or backward, according to the species. The largest cerebellum is to be met with in Mormyridae, to which belong *Mormyrus kanume, Petrocephalus sp.* and *Gnathonemus cyprinoides,* inhabitants of muddy water and swimmers in thickets of water-plants. They do not swim quickly, but are very nimble and vivacious with constant movements of fins, as they wind their way between the aquatic plants. The cerebellum of the Mormyridae is most hypertrophic and overlies all other parts of the cerebrum in the same manner as the human cerebrum is excessive in growth compared with that of other mammals.

Let us consider the cerebella of mammals which live in water, such as the whale, the seal, the otter, etc. As compared with fishes they all have a much better developed cerebellum, especially the seal, which is less accommodated to life in water and whose nimble movements we all know. Life in water leads, generally speaking, to atrophy of the cerebellum and particularly of the vermis or middle lobe, while the hemispheres remain in good condition.

The human cerebellum is well developed for the purpose of upright walking, because it is much more difficult to maintain bodily equilibrium on two feet than on four. Moreover, in the human being it regulates the coordination of speech. Not only the movements of tongue, lips and vocal cords must be well coordinated, but also the superficial and deep sensibility of mouth, throat and larynx must be well developed. Great orators need not only a well-developed center for articulate speech in the cerebrum, but also a well developed cerebellum, so that the cerebellum shall work under the control of the cerebrum and vice versa.

KINNOSUKE MIURA
IMPERIAL UNIVERSITY OF TOKYO

WORK OF THE NATIONAL RESEARCH COUNCIL

(Continued)

Division of Research Extension.—The council's division of research extension, which is especially interested in the promotion of industrial research, has been the special representative of the council in connection with its relation to the organization of the Crop Protection Institute, the Horological Institute and the important committees on corrosion problems, alloys problems, textiles research, the making and use of scientific instruments, etc. The officers of this division have also the special function of the active solicitation of funds from industrial concerns and other organizations and men for the support of any and all of the council's special projects which relate to the applications of science, whether these projects are directly under the control of the division of research extension or of other divisions, as those of physics, chemistry and chemical technology, biology and agriculture, etc.

The division has been specially active during the past year in arranging for certain important conferences, in promoting the financial support for the International Tables of Critical Constants and for the

Marine Pilings Investigations; in developing in co-operation with the U. S. Bureau of Standards and the American Home Economics Association a program for textiles research, in finding money from industrial companies for the preparation and publishing of a revised edition of the council's important bulletin on American research chemicals, and other similar undertakings.

Research Information Service.—The council's research information service, which serves as a clearing house for information concerning research work and workers, has built up a considerable equipment in the way of mechanisms for collecting, arranging, cataloguing and distributing information. During the past year it has answered about 2,000 outside requests for information, besides as many from the council offices and from institutions and men in Washington. It has compiled and published in the council's bulletin and reprint and circular series a considerable amount of information useful to research workers and scientific men generally, especially in the way of lists of published and unpublished (manuscript) bibliographies in various special scientific fields as well as a number of bibliographies both published and unpublished, but available for reference. It has also prepared and published an account of handling personnel data, and an account of methods of author's automatic abstracting.

The personnel file of American scientific investigators has been steadily increased during the past year. It now includes about 14,000 records. A summary of the activities of American psychologists has been prepared for publication. Progress has been made in the development of a general catalogue of sources. Progress has also been made on assembling matter for revisions of two earlier important informational publications of the service, namely, "Funds available in the United States for the encouragement of scientific research" and "Research laboratories in industrial establishments of the United States, including consulting research laboratories."

In the latter part of July and August, 1922, Mr. J. David Thompson of the service visited about three fourths of the industrial research associations in England, organized by means of government aid, and collected valuable data concerning their work, particularly their research informational activities. Mr. Thompson also prepared a special report on the scientific informational services of the world.

Division of Physical Sciences.—The council's division of physical sciences has devoted during the past year, as during the two years before, its principal attention and support to the work of the important series of special committees on various particular physical, astronomical and mathematical subjects or fields, whose work has been made possible by a gift of $30,000 from the Rockefeller Foundation for the first two years and an appropriation by the council of $5,000 for this past year. These committees have been composed of eminent specialists in their respective particular fields who have given much time and energy to the work of the committees. The following is a list of the fields of work of these committees: acoustics, algebraic numbers, atomic structure, celestial mechanics, electrodynamics of moving media, luminescence, mathematical analysis of statistics, orbit theory, parallaxes, photo-electric effects, physiological optics, quantum theory, radiation in gases, research methods and technique spectroscopy, theories of magnetism, thermo- and magneto-electrical effects, vision and photo-biology, x-rays and radio activity and x-ray spectra.

The carefully prepared reports of seven of these committees have been published during the past year in the council's bulletin series. Altogether thirteen reports have been published. The report of the Committee on the Mathematical Analysis of Statistics is to be published in book form by Houghton, Mifflin and Company.

Division of Engineering.—The council's division of engineering, through which the council maintains its contacts with the major engineering societies of the country and especially closely with Engineering Foundation, has been reorganized during the year consequent upon certain changes in the organization of Engineering Foundation. By the new arrangement, Dr. F. B. Jewett, vice-president of the Western Electric Company, becomes chairman of the division of engineering; and the president of the foundation becomes *ex-officio* a member of the executive board of the National Research Council.

The various activities and special research projects of the division of engineering are too numerous to mention with any approach to completeness in this report, but reference may be made to a few of them. Altogether there are now about twenty special boards and committees of this division.

The Advisory Board on Highway Research, which has been working in close cooperation with the U. S. Bureau of Public Roads, has made a number of reports of its work which have been published. It held its second annual meeting in Washington, November 23, 24, 1922, with a large attendance of leading highway engineers. Investigations of highway problems involving expenditures of more than one million dollars are now under way in America under the direction of various federal and state bureaus. The advisory board through its director and committees has been active in stimulating these investigations and has given much helpful information and advice in connection with them.

The work of the various committees of the Advisory

Board on Welding Research has made much progress during the year. The Committee on Pressure Vessels, for example, has been able to finance its work to the extent of about $15,000 by gifts from eight manufacturing concerns, and through cooperation with the U. S. Bureau of Standards, has completed a special research involving the testing to destruction of forty pressure tanks by the bureau. The committee on welded rail joints has instituted a comprehensive research involving, with contributed materials and services, the use of a sum exceeding $80,000. Steel companies, manufacturers of special joints, electric railway companies, university laboratories, U. S. Bureau of Standards, and various technical societies are cooperating in this work.

In connection with the work of the important joint committee of the Division of Engineering and the Division of Biology on marine pilings investigations, money and service contributions have been received from numerous sources. The most recent of these items has been the pledge of an appropriation of $10,000 each from the Quartermaster Corps of the Army and the Bureau of Yards and Docks of the Navy to be expended on work by the Chemical Warfare Service through two years.

The committee on fatigue phenomena on metals, which has been carrying on an important research in the laboratory and under the direction of Professor H. F. Moore, of the University of Illinois, has been well supported financially and has made conspicuous progress. In addition to original contributions of $30,000 each by Engineering Foundation and General Electric Company together with service, facilities and supplies from the University of Illinois and several corporations approximating $25,000, the General Electric Company has recently added $7,500 and informally indicated its willingness to appropriate $7,500 more if other industries will contribute a total of $15,000. Plans have been made for extending the investigation to non-ferrous metals besides continuing the studies on steels.

The committee on Neumann bands prepared a report which was published by the American Institute of Mining and Metallurgical Engineers. This committee is continuing its investigations with the cooperation of the Army and Navy to ascertain whether the presence of Neumann bands in steel is an evidence of weakness.

The committee on hardness testing of metals, the work of which is of especially fundamental nature, has made certain reports and has secured effective cooperation in its work from government laboratories, industrial companies and the American Society for Steel Testing. The committee on heat treatment of carbon steel has prepared a comprehensive report of its work which is to be published in the Transactions of the American Institute of Mining and Metallurgical Engineers. This committee has been recently reorganized for the purpose of completing the work originally outlined for it under the chairmanship of the late Dr. Henry M. Howe, and of planning new investigations of a fundamental nature.

The molding sands committee is making active progress with its work. Cooperation has been secured from state geological surveys for recording foundry sand deposits. Standard tests have been prepared for fineness and special progress has been made in determining standard methods for chemical analysis, rational analysis, permeability tests and sampling.

The full time services of a secretary have been provided for the committee on pulverizing through the cooperation of the U. S. Bureau of Mines, University of California and Massachusetts Institute of Technology. It is estimated that the total funds and services so far made available to this committee amount to more than $50,000 a year.

Division of Chemistry and Chemical Technology.—The council's division of chemistry and chemical technology has given much of its attention and energy during the past year to advancing the interests and work of the International Critical Tables of Chemical and Physical Constants. The present chairman of the division is the editor-in-chief of the Tables, and has associated with him a staff of two associate editors, two assistant editors and a group of ten corresponding editors representing as many European countries. This editorial board is now steadily at work and has completed its plan for the whole program. It has arranged with about a dozen physicists in as many different American colleges and universities to undertake special investigational work on the physical properties of various materials. Close cooperation with the international board of annual critical tables, with headquarters in Paris, has been set up. The total expense of the work of preparing and publishing the International Tables is estimated at about $200,000, of which about $100,000 in money and services have been so far pledged and partly paid in and rendered.

The division's committee on explosives investigations has been very active during the year and important reports of its work have been published. The committee has given a special attention to the matter of the utilization of surplus explosives now in the hands of the government and has shown by experimental demonstration how these explosives may be safely and advantageously employed in the industries. Through the work done by this committee on TNT, modified TNT and picric acid it is officially stated that more than $10,000,000 worth of useful explosives material has been rescued from waste.

The committee on chemistry of colloids has completed a bibliography of the literature in this field, containing eighteen hundred references together with brief descriptive statements of the ground covered by each paper. Also a list of research problems in colloid chemistry was prepared by the chairman of the committee and has been in great demand, the first edition having been already exhausted in meeting requests for it. The committee on research chemicals has arranged for a revision of the council's bulletin on "American Research Chemicals." Part of the expenses of this revision and its publication will be met by gifts which have been pledged by various chemical manufacturers. The first report of the committee on contact catalysis has been published in the Council's Reprint and Circular Series.

Division of Geology and Geography.—The council's division of geology and geography has, during the year, brought several of its current undertakings to approximate conclusion. The important work of Dr. Ernest Antevs on "The Recession of the Last Ice Sheet in New England," which was first taken up and supported by this division and later supported by other organizations, has been finished and published in the Research Series of the American Geographical Society. A bibliography of published geological bibliographies has been completed, in cooperation with the Research Information Service, and published. The work of preparing and classifying a list of American working geologists and geographers is practically completed. Considerable time has been given to cooperation with the Federal Bureau of Surveys and Maps in an effort to bring about the completion of the topographic maps of the United States.

In response to requests from petroleum geologists, working in the field, for means to enable them to be placed in touch with laboratory and university workers on the principles and theory of petroleum formulation and accumulation, a special committee of the division is undertaking to list and describe all researches in geology, physics, chemistry and biology which should be of use to the theoretical student of petroleum geology. Efforts have been made to encourage the preparation of geological abstracts. It has been definitely agreed by the division and the U. S. Geological Survey that the division will participate in the survey's undertaking to prepare a dictionary of the technical terms used in physiography.

Preliminary work has been done by the chairman of the division looking toward a plan for conserving and ultimately publishing the valuable scientific results of commercial explorations, especially by American companies, in foreign countries. There has been much unreasonable secrecy and ultimate loss of information in connection with such work. The publication of certain results of the House Inquiry jointly by the division and the American Geographical Society has been brought to completion. The division has approved as a project the preparation of a complete catalogue of all maps of Latin America by the American Geographical Society and the council has made a small appropriation through the division for this purpose. Considerable preliminary work has been done on a subject involving shoreline studies. The plan contemplates the cooperation of various government bureaus, several state surveys and state universities. The ultimate aim of the work is the forecasting of future changes of the shoreline.

The division arranged for four conferences to be held under the auspices of the division in connection with the mid-winter meetings of the various national societies of geology and geography. Three of these conferences have reference to the work of the division's committees on tectonics, sedimentation and geography. The fourth was a general round-table of geologists and geographers in which the work of the division was discussed.

Division of Medical Sciences.—The council's division of medical sciences has given much of its time and attention during the past year to the important matter of the administration of the research fellowships in the medical sciences which the council is enabled to maintain through the financial assistance of the Rockefeller Foundation and the General Education Board. Thirty-one fellows have so far been appointed. The chairman of the division, who is also chairman of the fellowship board, has recently made a trip of visitation to all the active fellows and he states that after careful inspection of the work of each one, after approximately six months of activity, he believes that no significant mistake was made in any individual appointment.

The division has carefully considered and approved a report of the Committee for Research on Sex Problems outlining the work accomplished during the past year and proposing a plan for the work in the future. (See reference to this committee earlier in this report.) The division's committee on abstracting current medical literature is recommending that all editors of medical journals in this country be requested to ask or require that an author's abstract of each article be sent with the article. This is in line with the important movement now being forwarded by other divisions of the council toward the development of an abstracting system in connection with scientific publication in this country.

The committee on investigation of deaths from tuberculosis in Colorado has presented a report which meets the warm approval of the division. This committee has undoubtedly made an important contribution to the epidemiology of tuberculosis and particu-

larly to the knowledge of the beneficial effect of climate in reducing the mortality from this disease. This extensive work has been carried out expeditiously and economically on the basis of a grant of $1,000 from the council.

Division of Biology and Agriculture.—The council's division of biology and agriculture has been much gratified by the recent successful outcome of negotiations with the Rockefeller Foundation which have resulted in the gift by the Foundation of $325,000 for the establishment and maintenance during the five-year period, July 1, 1923–June 30, 1928, of a series of research fellowships in the biological sciences, including anthropology and psychology. The special board of control has already been organized and has so far appointed nine fellows.

In addition the division has at its disposal nine special research fellowships for the scientific study of the uses of sulphur in agriculture, which are supported by certain industrial sulphur companies, and a single special research fellowship for the support of the work of Dr. Just, a negro biologist of Howard University, the funds for which are provided by Mr. Julius Rosenwald, of Chicago.

The division's committee on the Relations of Insects to Flowers carried on planned field work in Colorado last summer, the results of which have been published in a number of papers. This work was accomplished by the cooperation and support of the council, the American Museum of Natural History, Cornell University and the University of Colorado. The Committee on Food and Nutrition has carried forward and arranged for publication the work on protein metabolism in animal feeding begun under the leadership of the late Dr. H. P. Armsby. The results of investigations in the field of human foods carried on with the aid of a grant from the National Glass Containers' Association have been prepared for publication. Of the special funds available to the Committee on Food and Nutrition, $2,000 have been assigned to work on the relation of fertility to nutrition to be carried on under the direction of Dr. H. N. Evans, of the University of California.

The work of the Committee on Atmosphere and Man has made arrangements with the National Industrial Conference Board for the carrying on of extensive experimentation on the relation of atmosphere in factories to the efficiency of workers. The expense of the investigation will be provided by the National Industrial Conference Board.

As a culmination of the activity of the American phytopathologists over a rather long period and after a final conference in December, 1922, a project for the establishment of a scientific institute, to be known as the American Tropical Research Institute, was presented to the division and approved by it. The council has provided a small sum for an organizing meeting of a committee on phytopathology in the tropics and their advisers to formulate definitely the plans for the institute. Assurances of financial support have been received from commercial companies interested in tropical agriculture.

Division of Anthropology and Psychology.—The council's division of anthropology and psychology actively cooperated with the division of biology and agriculture and with the secretary's office in the negotiations concerned with the establishment of the research fellowships in the biological sciences, which are interpreted to include both anthropology and psychology, and which have been referred to earlier in this report.

The council's important Committee on Scientific Problems of Human Migrations, also earlier referred to in this report, had its origin in the division of anthropology and psychology and the division has given much attention to its program of work. An important conference on the subject of this committee's interest was held in the council rooms on November 18, 1922, which was attended by a distinguished group of men representing the fields of biology, psychology, medicine, public health, sociology and economics.

The division's important committee on vestibular research has been one of the council's most active committees and the results of its work have already been of high scientific value. It reports the preparation of an extensive comparative study of vestibular functions and the publication of experimental investigations on "Thresholds of Rotation," and the "Adequacy of Reflex Compensatory Eye Movements," and also "An Historical Survey of Vestibular Equilibration." The committee further reports the successful operation of the first clinical instrument for photographing the reflex vestibular deviations of the eyes of patients during rotation.

The Committee on State Archeological Surveys has prepared a brief manual to be used in connection with its work of interesting states in local archeological surveys. The Committee on Psychological Abstracts reports progress in its negotiations for the ultimate control by the American Psychological Association of an abstract journal which was initiated by the Psychological Review Company.

The Committee on Personnel Research in Business and Industry has cooperated in supporting the program of research on motivation in industry by Professor Elton B. Mayo, of Adelaide University, Australia, who has been in this country during the past year. The Committee has also cooperated with the Institute for Government Research in securing the services of Dr. L. L. Thurstone for the newly founded Bureau of Public Personnel Administration.

VERNON KELLOGG,
Permanent Secretary, National Research Council

SCIENTIFIC EVENTS

THE TWENTY-FIRST INTERNATIONAL CONGRESS OF AMERICANISTS

IN accordance with the resolution adopted by the Twentieth International Congress of Americanists held at Rio de Janeiro in 1922, the Twenty-first Congress will be held at The Hague and at Gothenburg.

Arrangements have been made for holding the first part of this congress in the Netherlands at The Hague from Tuesday, August 12, to Saturday, August 16, 1924, the second part to be held in Sweden at Gothenburg from Wednesday, August 20, to Monday, August 25.

The Hague session will deal with subjects of general nature, North America, the Antilles and Guiana. In Gothenburg papers will be read on subjects of general nature, South America, Central America and the Esquinaux.

Care will be taken to provide a means of conveyance from The Hague to Gothenburg at a reasonable charge. Side trips will probably be arranged to Stockholm, Christiania and Copenhagen; and following the session anthropological congresses of importance will be held in Prague. It is very desirable that titles and abstracts of communications be received both for The Hague and for Gothenburg at an early date so that the detailed program may be prepared as soon as possible.

Communications may be oral or written. The time allotted for the reading of papers is fifteen minutes; but exceptions may be made in the case of subjects of especial interest and importance. The acceptance of more than two communications by one author will be subject to decision by the council. For discussion of papers the time limit will be five minutes for each speaker. All papers presented at the session will be submitted, after the conclusion of the congress, to the committee of publication, and if approved will be printed, with a limited number of illustrations if necessary, in the proceedings of the congress.

The addresses of the Secretaries General of the two sessions are: Dr. D. Albers, Van Oldenbarneveltlaan 61, The Hague, Netherlands, and Dr. Erland Nordenskiöld, The Museum, Gothenburg, Sweden. Subscriptions (10 Dutch guilders and 15 Swedish crowns) may be sent either to the secretaries, or to Dr. Aleš Hrdlička, U. S. National Museum, Washington, D. C.

THE BOSTON MEETING OF THE AMERICAN PUBLIC HEALTH ASSOCIATION

THE Fifty-second Annual Meeting of the American Public Health Association was held in Boston, Massachusetts, October 8–11, 1923, with more than nine hundred sanitarians in attendance. The following scientific sections met to hear specially selected papers in their respective fields: Public Health Administration, Laboratory, Vital Statistics, Sanitary Engineering, Industrial Hygiene, Food and Drugs, Child Hygiene, Public Health Nursing, Health Education and Publicity.

There were two evening general sessions, one on October 8, and the other on October 10. The program of the first consisted of addresses of welcome from local health and civic leaders, including the Honorable James M. Curley and a representative of the governor, and the presidential address of Dr. E. C. Levy. A reception followed, at which there was dancing. At the second general session, Dr. George E. Vincent, president of the Rockefeller Foundation, talked on "Weighing the Ounce of Prevention"; Sir Thomas Oliver, the English industrial hygienist, presented a paper on "American leadership in safety and sanitation in modern industries"; and Dr. Linsly R. Williams, managing director of the National Tuberculosis Association discussed "Coordination of national health work."

Four meetings of the governing council of the association were held, and among other important matters of business, it was voted: (1) To hold the 1924 annual meeting in Detroit, Michigan. (2) To accept the New Jersey Sanitary Association as an affiliated state public health society. (3) To cooperate with the American Water Works Association in the preparation of standard methods for the examination of water. (4) To accept the hitherto provisional sections on public health nursing, and health education and publicity, as regular sections.

The association elected officers for the year 1923–1924 as follows:

President, William H. Park, M.D., New York City.
Vice-presidents, Francis X. Mahoney, M.D., Boston, Massachusetts; John W. S. McCullough, M.D., Toronto, Ontario; William H. Davis, M.D., Washington, D. C.
Treasurer, Roger I. Lee, M.D., Boston, Massachusetts.
Executive secretary, James A. Hayne, M.D., Columbia, S. C.

The office of executive secretary was made an unsalaried and honorary post, and the title of the executive officer was changed to general secretary. Mr. Homer N. Calver, who has been the acting executive secretary, was appointed to this office.

SEMINAR ON CONTEMPORARY CHEMISTS

THE Department of Chemistry of the University of Pittsburgh has arranged a seminar to be conducted on Fridays at 2.20 p. m. in Thaw Hall. Twenty-four contemporary European chemists are the topics of discussion during the year. The graduate student is expected to present a biographical sketch of the chemist assigned to him, followed by a discussion of his

most important publications. Wherever possible the student is requested to exhibit a recent photograph and publications of the scientist under discussion. A typewritten copy of the matter to be presented must be submitted to the professor in charge of the field of chemistry covered, on the Saturday preceding the seminar period.

While this course is intended primarily for graduate students majoring in chemistry, others interested in any of these topics are cordially invited to attend the seminar. The program is as follows:

Oct. 5, 1923	—J. L. Young	H. G. J. Moseley
Oct. 12, "	—J. E. Rosenberg	F. W. Aston
Oct. 19, "	—A. N. Parrett	F. Soddy
Oct. 26, "	—W. L. Nelson	M. & Mme. P. Curie
Nov. 2, "	—E. W. Felkel	Niels Bohr
Nov. 9, "	—J. Nevyas	W. Nernst
Nov. 16, "	—E. W. Ohl, Jr.	Wilhelm Ostwald
Nov. 23, "	—R. A. Gagnon	J. Perrin
Dec. 7, "	—E. R. Clarke	T. Svedberg
Jan. 4, 1924	—W. A. S. Wright	Wolfgang Ostwald
Jan. 11, "	—R. McClure	K. Szigmondy
Jan. 18, "	—W. A. Rudisill	P. Sabatier
Jan. 25, "	—J. Lebarthe	W. Ramsay
Feb. 8, "	—A. H. Weitz	J. H. Van't Hoff
Feb. 15, "	—W. W. Lewers	M. LeBlanc
Feb. 29, "	—L. D. Myers	S. Arrhenius
Mar. 7, "	—R. E. Flikkema	E. Fischer
Mar. 14, "	—J. F. Conn	H. von Baever
Mar. 21, "	—H. J. Robertson	F. Haber
Mar. 28, "	—C. G. Denny	H. Moissan
Apr. 4, "	—A. E. Wood	P. Ehrlich
Apr. 11, "	—E. S. Ross	J. W. Mellor
Apr. 25, "	—G. D. Kammer	G. Lange
May 2, "	—Miss L. V. Hjort	L. Pasteur

THE AMERICAN SOCIETY OF ZOOLOGISTS

THE American Society of Zoologists will hold its twenty-first annual meeting at Cincinnati from Thursday to Saturday, December 27–29, 1923. The society headquarters will be at the Hotel Gibson which will also serve as headquarters for the botanists, naturalists and geologists.

Professors N. K. Koltzoff and P. P. Lazareff, of Moscow, will be the guests of the society at these meetings. The former will speak on Thursday afternoon at four P. M. on the subject: "Experimental zoology and the Moscow Institute." The latter will speak at the same time on the following day on: "The theory of nervous activity and the theory of sight."

A symposium on "Morphogenesis" has been arranged for Saturday afternoon in conjunction with the botanists and naturalists. Professors Child, R. S. Lillie, Buller and Harper will speak.

Through an agreement of long standing the arrangement of the zoological aspect of the program of Section F of the American Association rests with the American Society of Zoologists when the two meet together. Zoologists who are not members of the society may have papers placed on the program if sponsored by some member. All titles submitted for the program must be accompanied by an abstract of not more than 250 words and must reach the secretary by November 20. Titles and abstracts on all phases of zoology, evolution included, other than genetics should be sent directly to the secretary. Titles and abstracts in genetics should be sent to Dr. D. F. Jones at the Connecticut Agricultural Station, New Haven, Conn.

The abstracts will be published in the *Anatomical Record* preceding the meeting and reprints will be available for distribution before the meetings convene. Persons desiring these abstracts sent them on publication may order them from the secretary at a cost of thirty cents per copy.

W. C. ALLEE,
Secretary
ZOOLOGICAL BUILDING,
THE UNIVERSITY OF CHICAGO

DEDICATION OF THE STEINHART AQUARIUM

THE Steinhart Aquarium of the California Academy of Sciences was formally dedicated and opened to the public on Saturday afternoon, September 29, 1923.

The exercises were held out doors in the large court in front (north side) of the building which is located in Golden Gate Park, San Francisco, adjoining the museum of the California Academy of Sciences. An audience of more than five thousand was present.

Brief addresses were given by: Honorable C. E. Grunsky, president of the academy; Honorable Wm. H. Crocker, president of the Board of Trustees; Honorable William Sproule, president of the Southern Pacific Railroad Company and member of the Board of Park Commissioners; Honorable James Rolph, Jr., mayor of San Francisco; Dr. David Starr Jordan, chancellor emeritus Stanford University, and Dr. Barton Warren Evermann, director of the Aquarium. Music was furnished by the Park Band. The address given by Dr. Evermann will be published in *The Scientific Monthly*.

The Steinhart Aquarium is proving the most popular attraction in San Francisco, the number of visitors daily reaching more than 25,000.

SCIENTIFIC NOTES AND NEWS

THE degree of doctor of science has been conferred by the University of Wales on Sir Charles Sherrington, president of the Royal Society.

DR. HIDEYO NOGUCHI, of the Rockefeller Institute for Medical Research, has been elected to membership in the Imperial Academy of Japan.

DR. CLIFTON D. HOWE, dean of the faculty of for-

estry of the University of Toronto, has been elected president of the Canadian Forestry Association.

PROFESSOR R. A. SEATON, dean of engineering in the Kansas State Agricultural College, was elected president of the Kansas-Nebraska section of the Society for the Promotion of Engineering Education at the annual meeting held at Lincoln, Nebr., on October 20 and 21.

JOHN HOWE HALL, of the Taylor-Wharton Iron & Steel Company, of High Bridge, N. Y., has been awarded the J. H. Whiting gold medal of the American Foundrymen's Association at its recent meeting, for outstanding achievements in metallurgy.

IN connection with the celebration of the centenary of the birth of Pasteur, the French government has made awards in "La Légion d'honneur" of 2 "grands officiers, 9 "commandeurs," 28 "officiers" and 52 "chevaliers."

MEMBERS of the Pasteur Institute, Paris, were awarded promotions as follows: M. Calmette, "grand officiers, 9 "commandeurs," 28 "officiers" and 52 Radot, "commandeurs"; MM. Fernbach, Fourneau, Marie, Mesnil, Prévot, Tourtel, Dr. Veillon, "officiers." Drs. Abt, A. Berthlot, Besredka, Dumas, Duclaux, Dujaric de la Rivière, Pozerski, Weinberg, MM. Boquet, Danysz, Pontenay-Fontête, Mlle. Ledebt, MM. Ramon, Viala, Agulghon, Cesari, "chevaliers."

DR. ARTHUR S. RHOADS, pathologist of the Missouri State Fruit Experiment Station, has accepted the position of assistant plant pathologist of the Florida Agricultural Experiment Station.

RICHARD FISHER, formerly of the department of chemistry of the University of Illinois, and William B. Plummer, formerly research chemist of the Grasselli Chemical Co., have joined the research staff of the Combustion Utilities Corp., Long Island City, New York.

THE National Lamp Works of General Electric Company in entering upon a policy of general reduction and retrenchment in home office expenses has felt obliged to restrict the scope of its scientific research to problems bearing more immediately upon its chief business interests. In consequence the company has reluctantly decided to discontinue the research work in biology in Nela Research Laboratories, a research section recently established under the direction of Dr. Ralph S. Lillie, with Dr. Samuel E. Pond as associate, and Dr. Marie Hinrichs as research assistant. This decision affects not only the biological work at Cleveland but that which has been conducted during the summer months in the company's laboratory at Woods Hole, Mass.

DR. W. H. PERKIN, of the University of Oxford, engineer and director of research for the British Dyestuffs Corporation, Limited, has been appointed director of research of the corporation to succeed Professor A. G. Green, who recently resigned.

WE learn from *Nature* that Mr. A. Eastham, who has held botanical and seed-testing appointments in Canada, has been appointed to be chief officer of the Official Seed Testing Station for England and Wales.

DR. CHARLES H. HERTY, president of the Synthetic Organic Chemical Manufacturers' Association, has sailed for a short visit to Europe.

OTTO H. SWEZEY, entomologist, and Gerril P. Wilder, botanist, have completed for the present their investigations in Samoa and have returned to Honolulu. In addition to conducting investigations relating to economic problems, collections were made for Bishop Museum.

PROFESSOR R. B. THOMSON, of the University of Toronto, who has been interested in the establishment of botanical gardens in Toronto, has been granted leave of absence by the university until February, that he may visit Australia and New Zealand. Professor Thomson read a paper at the Liverpool meeting of the British Association as a delegate from the Royal Society of Canada.

DR. GEORGE OTIS SMITH, director of the U. S. Geological Survey, addressed the Boston Section of the American Institute of Mining and Metallurgical Engineers on October 16, on "Lessons from the coal commission's work."

DR. H. W. WILEY gave an address in Pittsburgh on the evening of October 26, before the Langley Science Teachers' Association, on the "Relation of nutrition to biology."

PROFESSOR A. BIEDL, of the University of Prague, will give the Harrington Lecture at the University of Buffalo on Saturday, November 10.

PROFESSOR W. D. TREADWELL, of the Technical High School, Zurich, lectured on "Electrometric methods in analytical chemistry" on November 2, under the auspices of the Manchester sections of the Society of Chemical Industry, the Institute of Chemistry, the Society of Dyers and Colorists and the Manchester Literary and Philosophical Society.

DR. H. FREEMAN STECKER, professor of mathematics in the Pennsylvania State College, died on October 30, aged fifty-six years.

DR. BORIS SIDIS, known for work in psychopathology, died at his home in Portsmouth, N. H., on October 25, aged fifty-six years.

PROFESSOR HERBERT MCLEOD, F.R.S., distinguished

as a chemist, physicist and scientific bibliographer, died on October 1, aged eighty-two years.

DR. JOHN ALLEN HARKER, F.R.S., chief assistant and head of the Thermometry Division of the British National Physical Laboratory, died on October 10, aged fifty-three years.

THE Astronomy and Physics Club, of Pasadena, began its third year on October 5, the program for the month is: October 5, "Report on the Liverpool Meeting of the British Association and on the condition of scientific work in Europe," Dr. Paul S. Epstein. October 12, "The Hall-effect and specific resistance of cathodically sputtered films," Dr. Stewart S. Mackeown. October 19, "The Errors of Diffraction Gratings," Dr. John A. Anderson. October 26, "The ruling of diffraction gratings, Dr. John A. Anderson.

LECTURES are being given during November at the New York Botanical Garden on Saturdays and Sundays at 3:30 p. m., as follows:

November 3—"Mountain scenery of the United States and Mexico": Mr. Le Roy Jeffers.
" 4—"Rare pines and firs": Mr. K. R. Boynton.
" 10—"Botanical rambles in Panama": Dr. M. A. Howe.
" 11—"The origin of cultivated plants": Dr. A. B. Stout.
" 17—"Ferns": Dr. R. C. Benedict.
" 18—"Java and the Javanese people": Dr. H. A. Gleason.
" 24—"A trip to Ecuador": Dr. F. M. Chapman.
" 25—"British Guiana": Miss Ruth Rose.

IT is proposed to establish a Banting Medical Research Foundation, plans for which were announced on October 31, at London, Ontario. Dr. Banting was the first contributor to the proposed $1,000,000 fund, having signified his intention to donate $10,000, a portion of his share of the 1923 Nobel Prize. A committee to take preliminary charge of the foundation and its financing includes John Rogers, of Toronto, chairman; Dr. Stewart, president of the New York Academy of Medicine; Professor Fitzgerald, University of Toronto, and Dr. George W. Ross, of Toronto.

Chemical and Metallurgical Engineering reports that a new chemical and physical research laboratory is planned by the National Tube Company, of Pittsburgh. It will be situated on Forbes Street, adjoining property held by the federal government, including the United States Bureau of Mines. A small tract of government property is needed to square the site for the proposed building, and application has been made at Washington for the transfer of the land.

THE editorial office of International Critical Tables has finished the preparation of a table of the viscosity of water at 1° intervals between 0° and 100° C. This table is based upon a thorough and critical evaluation of all the data available on the subject. While prepared primarily for the use of the cooperating experts of the International Critical Tables, a number of extra copies are available. Copies of the sixteen-page pamphlet entitled "Fundamental Constants and Conversion Factors" are also available. This pamphlet contains the latest data on the fundamental constants of nature, including definitions, dimensional equations, conversion factors, etc.

THE *Journal* of the American Medical Association states that under the direction of the national public health service and under the auspices of the Spanish Cancer Research Society, an institution has been opened for the study of cancer at Madrid. The clinical section includes twenty-eight beds, with rooms for operations and medical treatment, and a free outpatient service. There is a complete installation for radiotherapy and radiologic diagnosis. The section of anatomy, pathology and bacteriology includes several laboratories, as also the chemical section. The institution is mainly supported by the government, but part of the running expenses is paid by the patients and private donations. Dr. J. Govant is medical director.

THE *British Medical Journal* reports that the Advisory Committee on Industrial Hygiene, which has just ended its sittings at the International Labor Office of the League of Nations at Geneva, adopted a resolution stating that the most effective method of securing the success of research into the prevention of anthrax would be the constitution of national committees to work under the general direction of the Health Committee of the League of Nations. Members might be appointed after consultation between the Health Committee of the League of Nations and the government departments in each country which are responsible for the administration of the Factory Acts. Dr. Smyth, assistant professor of industrial hygiene at the University of Pennsylvania, described his method of iodine disinfection to the committee, which expressed the hope that his observations would be followed up. The committee also discussed the possibility of sterilization of the effluents of tanneries.

WE learn from *Nature* that an Empire Mining and Metallurgical Congress is to be held at the British Empire Exhibition in London during the first week in June, 1924. The Institution of Mining and Metallurgy, the Institution of Mining Engineers, the Institution of Petroleum Technologists, the Iron and Steel Institute and the Institute of Metals, representing the scientific and technical interests of the mineral and metal industries, with the Mining Association of Great Britain and the National Federation of Iron and Steel

Manufacturers, are cooperating as conveners of the Congress. This is the first such congress to be held, and it is anticipated that succeeding sessions will be held in the Dominions under the auspices of an Empire Council of Mining and Metallurgical Engineering Institutions, which it is hoped will be constituted as a result of the inaugural congress. Viscount Long of Wraxall will deliver the Sir Julius Wernher Memorial Lecture of the Institution of Mining and Metallurgy at the opening session, taking mineral resources and their relation to the prosperity and development of the Empire as his subject. The May Lecture of the Institute of Metals to be delivered by Dr. F. W. Aston, on "Atoms and isotopes," will also form part of the program.

TWENTY leaders in the American pulp and paper industry have been asked by Secretary of Agriculture Wallace to form an advisory committee to work with the United States Department of Agriculture in formulating and carrying out its forestry policies which relate to the supply and use of timber in making paper and kindred products. Hugh P. Baker, secretary of the American Pulp and Paper Association, has been active in the formation of the advisory committee and has conferred concerning the matter with Chief Forester Greeley and E. H. Clapp, director of research for the Forest Service. Secretary Wallace states that the creation of an advisory committee composed of men intimately concerned with the pulp and paper industry will, in his opinion, insure thorough consideration of requests for advice as well as bring forth advice itself which would deal in a searching and practical way with the fundamental problems of the industry. Among the activities of the department closely concerned with the pulp and paper industry are the research in pulp and paper-making conducted at the Forest Products Laboratory at Madison, Wis., forest research in the growing of timber crops now under way at the various forest experiment stations, and the development of federal and state policies for the production of timber upon the country's forest lands.

HITHERTO the mathematical, physical and biological papers submitted to the Cambridge Philosophical Society have been published in one series of proceedings. In order to facilitate the publication of the results of biological research carried out in Cambridge, it has been decided to attempt the publication of a separate series of *Biological Proceedings*. The new series will consist largely of papers representing the results of completed work, and notices of preliminary investigations will be added as an appendix. The following constitute a committee to whom papers are referred prior to publication: H. R. Dean, F. G. Hopkins, A. C. Seward, J. T. Wilson, J. Barcroft, J. Gray, T. C. Nicholas and F. A. Potts.

UNIVERSITY AND EDUCATIONAL NOTES

TWO Atlanta women have left large legacies to Atlanta colleges. Miss Jane Walker Inman left $259,000 to Agnes Scott College to be used in establishing an endowment in honor of her brother. Mrs. Robt. J. Lowry left $275,000 to Ogelthorpe University to establish a school of commerce and banking in honor of her deceased husband, Colonel Robt. J. Lowry.

EDGAR ALLEN, formerly of Washington University, St. Louis, has been appointed professor of anatomy at the University of Missouri.

FRANK A. FERGUSON, associate professor of physics at Rutgers College, has been appointed head of the department of physics of the Connecticut Agricultural College.

JOHN L. BRAY has resigned his position as metallurgist with the U. S. Tariff Commission to accept the professorship in metallurgy at Purdue University.

DR. JOSEPH P. HETWER and Dr. Harry A. Beckman have been appointed instructors of physiology and pharmacology, respectively, in the Marquette Medical School.

WALTER C. KRAATZ, PH.D. (Ohio State University, '23), who has been instructor in the department of zoology at Ohio State University, is this year assistant professor and acting head of the department of zoology at Miami University, during the leave of absence of Professor S. R. Williams.

PROFESSOR JOHN READ, of the University of Sydney, and Professor Adam Patrick, of the University of Glasgow, were installed in the chairs of chemistry and medicine, respectively, at the University of St. Andrews on October 5.

DR. JAMES FRANCK has been appointed to the chair of physics in the University of Berlin, vacant by the death of Dr. Heinrich Rubens.

DISCUSSION AND CORRESPONDENCE

ACTIVE HYDROGEN BY ELECTROLYSIS

IN 1907 Fischer and Massenez[1] obtained a concentration of 17 per cent. by weight of ozone when they electrolyzed a solution of sulfuric acid, using a very high current density. Since ozone can be produced by this method, it would seem probable that a high current density at the cathode might aid in the production of the ozone form of hydrogen. When a solution of sulfuric acid is electrolyzed, using the above principle, the hydrogen that escapes at the cathode contains an active constituent which combines with pure nitrogen to form ammonia. Some of the am-

[1] *Z. Anorg. Chem.*, 52, 202 (1907).

monia formed is collected in the absorption bulb, but quite a large portion of it is dissolved by the sulfuric acid solution. This active constituent in the hydrogen that is evolved at the cathode is probably the ozone form, and is produced perhaps in a manner analogous to the ozone form of oxygen. The percentage of the active gas formed varies with the current density and the concentration of the acid.

Likewise, if a solution of potassium hydroxide is electrolyzed using a high cathode current density the escaping hydrogen contains the ozone form which combines with pure nitrogen to form ammonia.

In the electrolysis of the acid solution the escaping hydrogen contains a fog which persists after the gas has passed through the absorbing solution. This fog is similar to, but less dense than, the fog sometimes produced by ozone when it is bubbled through potassium iodide solution.

This work is a further verification of the theory of Dr. G. L. Wendt that triatomic hydrogen may be produced wherever atomic hydrogen is formed.

A. C. GRUBB

DEPARTMENT OF CHEMISTRY,
UNIVERSITY OF SASKATCHEWAN

SOLDNER, FOUCAULT AND EINSTEIN

IN your issue of August 31, pp. 161–163, you print Dr. Trumpler's defense of Einstein, yet as Trumpler does not touch at all upon one of my leading points, namely, Einstein's ignoring of Foucault's experiment of 1850, which disproved the emission theory of light —my criticism being that Einstein continued to use the emission theory as if it were lawful, whereas it has been outlawed now for 73 years—I will claim only a few lines of your space in order to supply Trumpler's omissions:

1. We do not deem it necessary to reply to Trumpler's labored defense of Einstein; his admissions are sufficiently damaging both to Einstein and to relativity. Soldner's paper bore the title, "Ueber die Ablenkung eines Lichtstrahls von seiner geradlinigen Bewegung durch die Attraktion eines Weltkörpers, an welchem er nahe vorbeigeht"—"On the deviation of a ray of light from its rectilinear motion through the attraction of a heavenly body near which it passes." Let this title speak for itself. I am willing to stand with Dr. P. Lenard, winner of the Nobel Prize in physics, long recognized as one of the leading physicists of our age.

2. Apparently Dr. Trumpler is unable to make a defense of Einstein in ignoring Foucault's celebrated experiment of 1850, showing that the velocity of light is less in water than in air, and therefore light is a *wave motion in the ether,* and is not corpuscular. It seems that Einstein, because he denies the existence of the ether, could not derive Soldner's formula of 1801, without adhering to the hypothesis of emission, that "Light is subject to gravitation." Soldner had a right to use the emission theory in 1801, half a century before Foucault's *experimentum crucis* of 1850; yet in 1911, Einstein was debarred, by every canon of science, from a similar procedure, because Foucault's work 60 years earlier had outlawed the corpuscular theory of light for all time. Thus Einstein's procedure in 1911–16 was wholly unlawful. The *Astronomical Society of France,* in the *Bulletin* for Sept., 1923, will take cognizance of the ignoring of Foucault's celebrated experiment.

T. J. J. SEE

MARE ISLAND, CALIFORNIA

No comment on the following note is required. I might request, however, that after reading it, the reader turn again to my note in the issue of SCIENCE for August 31, 1923, pp. 161–163.

ROBERT TRUMPLER

LICK OBSERVATORY

SIGMA XI

IN SCIENCE for October 5 I find on pages 259–260 a communication making certain statements regarding Sigma Xi.

It is said that "the policy of the Sigma Xi has been to refuse the granting of chapters to state colleges." This view is incorrect. Neither the convention nor the executive committee has ever directly or indirectly adopted any policy excluding or favoring one class of institutions above another. Both the executive committee and the convention have been very careful to consider every application absolutely on its merits. As a matter of fact at least one state college has been granted a chapter. I am confident that there is no prejudice either in the society in general or among the members of the executive committee against state colleges or any other particular group of institutions.

The other statements made concerning Sigma Xi involve comparisons the justification of which must rest on the judgment of the individual, but there are some who would dissent from other conclusions reached by the author of this communication.

HENRY B. WARD,
President

UNIVERSITY OF NEBRASKA

MODERN AND CLASSICAL GREEK

PROFESSOR EDWIN H. HALL has given in SCIENCE, Vol. LVIII, No. 1490, pp. 37–39, an eloquent and just tribute to the memory of his colleague and my admired classmate, Arthur Gordon Webster.

Dr. Hall refers in a footnote to Webster's addressing "in their own tongue assemblies of Greeks in Worcester." It should be stated, however, that this was not classical Greek. Webster succeeded where

one of Great Britain's famous prime ministers failed.

It is quite generally known that the Right Honorable Wm. E. Gladstone was an eminent Greek scholar, regarded as an authority in university circles. It is not so generally known that on one occasion he went to Athens to deliver an address in Greek. It was a long speech seemingly full of eloquent and loud-sounding periods. The audience applauded vigorously, but the applause was due to politeness, not comprehension, as those present thought that the orator was speaking English.

Each commencement we behold some vacant-eyed youth crowned with a *summa cum laude* in Greek, and we wonder as we look at him if he should be dropped down in some corner of Greece, whether he could tell the natives his name and where to take him.

ALEXANDER MCADIE

QUOTATIONS

MEDICAL RESEARCH IN INDIA

THE committee on retrenchment in India, over which Lord Inchcape presided, recommended, among other things, that the payment of research officers from central revenue should cease, and that the grant-in-aid to the Research Fund Association should be discontinued. The association had accumulated 33 lakhs, derived from the Government contribution and earmarked for a new central institute at Delhi; the committee advised that the interest on this sum should be used for the maintenance of medical research. The *Pioneer*, which is commonly credited with being well informed as to the intentions of the Government of India, stated in its issue of June 7 that it was understood that the Inchcape Committee's recommendations regarding the continuance of expenditure on medical research will not be accepted in their entirety. The adoption of the drastic proposals put forward by Lord Inchcape and his colleagues would, our contemporary continues, have involved "the virtual closing down of all research work in India, for, in the face of such a curtailment of activity, the chances of obtaining research workers in the future would have been small indeed. As it is, there is ground for the belief that the policy to be adopted will be that of securing a state of suspended animation. Thus instead of abolishing the appointments of twelve bacteriological officers, as recommended by the Retrenchment Committee, it is proposed to leave six of these appointments unfilled until financial conditions are more favorable. The establishment of a central research institute at Delhi and the grant of five lakhs a year to the Indian Research Fund Association are similarly suspended. This measure of retrenchment will be regretted, but it, at least, will not render the position hopeless, and it provides the retention of a nucleus for expansion when the occasion is suitable. The Directorship of Medical Research has been abolished for the time being, but arrangements are being made for that officer's duties to be carried on departmentally." The *Pioneer* goes on to express the opinion that if its prognostications prove to be correct, the Government of India has been able "successfully to temper its obsession on the subject of retrenchment with a due appreciation of the vital importance of medical research in a country like India." We can only express a fervent hope that this interpretation of the situation may prove to be correct; it does not seem to be a particularly courageous manner of dealing with a matter of so much importance. As we observed when the Inchcape report was first published, it is a paltry piece of economy to cut down the relatively small sum provided for the scientific study of the causes which lead to the high mortality among the 350 millions of the population of India. The amount represents an expenditure of about one twelfth of a farthing a head a year. The wisdom and policy of establishing a central medical research institute at Delhi is, we admit, open to doubt; it may be very much wiser to subsidize provincial institutes and special inquiries. It is easier to destroy than to build up, and even if a nucleus be retained the loss of experienced workers can hardly fail to make the eventual expansion more difficult.—*British Medical Journal.*

SCIENTIFIC BOOKS

Minéralogie de Madagascar, Vol. I and Vol. II. By A. LACROIX. Paris, Augustus Challamel, editeur, Librairie maritime et coloniale, 1922; Vol. I, 624 pp., 27 plates, one physical map in colors; Vol. II, vii, 694 pp., 29 plates and 11 maps in the text, 4to.

THE "Minéralogie de Madagascar," by Prof. Alfred Lacroix, of which the first and second volumes have appeared, is one of the most comprehensive studies of its kind that has been published, and gives us a wealth of information regarding the mineralogy and petrography of France's great island colony.

The first volume is devoted to the geology of the island, the first chapter giving a general idea of its geography (pp. 1–18). In the second chapter (pp. 19–148) the various geological aspects are described at considerable length under the sub-headings, "Region of Crystalline Schists" (pp. 19–51); "Sedimentary Formations" (pp. 52–56); "Intrusions and Post-liasic developments," "Recent Volcanoes" (pp. 77–150). This is followed by a section devoted to the mineralogy of the island (pp. 151–604).

The second volume treats of applied mineralogy, mining, etc. (pp. 1–218), of lithology (pp. 219–576).

The writer begins by noting that, after New Guinea and Borneo, Madagascar is the largest island of the

globe. It has an extreme length of 1580 kilometers (nearly 953 miles) and an extreme width of 580 kilometers (about 360 miles). Its area exceeds 600,000 square kilometers (231,660 square miles), while the area of France is but 212,659 square miles. The island was visited by the Arab travelers at an early date, and was known to Marco Polo, who wrote towards the end of the thirteenth century; he is said to be the first European or Asiatic author to use the name "Madagascar." Geologically, this vast area contains (1) a region essentially formed of the crystalline schists and eruptive intrusive rocks; (2) a region of sedimentary or volcanic rocks; (3) a small, but interesting zone, forming the eastern side of a narrow border of sediments and sand dunes. The crystalline massif, essentially mountainous, extends for nearly the entire length of the island.

Of the gems of Madagascar, the author notes that from its discovery the island was reputed to furnish gems, and in 1542 Jean Fonteneau, the second Frenchman to land there, declared that precious stones were to be found, while in 1658 Flacourt speaks of topazes, aquamarines, emeralds, rubies and sapphires, of course from hearsay. However, the mineralogist, Alfred Grandidier, who explored the island extensively in 1870, stated that the Madagascans had no idea of what a precious stone was, and that they only cared for colored glass beads. Indeed, Professor Lacroix says that the actual discovery of gem material hardly dates farther back than thirty years. In 1891, M. Grandidier gave the Muséum d'Histoire Naturelle in Paris some fine crystals of rubellite and a few small sapphires and zircons.

As a result of several years of exploitation, it can be said that the beryls are the finest of the Madagascar gems, and they now constitute the chief part of the precious stone product. Many fine blue beryls have been found, but the choicest are unquestionably the cesium beryls of a peach-blossom pink hue, the type on which the writer of the present notice has bestowed the name "morganite." These and other of the beryls of greatest density are found in the sodolithic pegmatites, and since the deposits of Maharitra have become exhausted, the beryls now in commerce come principally from the eluvions of Anjanabonoina. In the British Museum there is a splendid cut beryl from Madagascar, weighing 600 carats, with a density of 2.835, and the American Museum of Natural History in New York owns a magnificent cut example of the morganite type, weighing 57½ carats, the density being 2.827. Professor Lacroix believes that both of these came from Anjanabonoina. He also believes that he was the first to have Madagascar stones cut, at the time the products of the island were exhibited in the Muséum d'Histoire Naturelle. These gems were chrysoberyls, garnets, corundums and topazes. Tourmalines occur in great variety (Vol. I, pp. 411–442; Vol. II, pp. 92–95) and of many beautiful hues, the red variety (rubellite) being the most precious. Specimens from Antandrokomby, Ampantsikahitra and other localities have furnished fine gems. Those of a golden yellow or a lemon-yellow are among the most characteristic; these are found principally in Tsilaizina. A number of exceptionally fine examples of lithia tourmalines are shown on Plate 9, Vol. II. The long list of Madagascar gem stones includes the following: beryl, tourmaline, both in a great variety of colors, kunzite, garnet, spinal, chrysoberyl, zircon, cordierite, diopside, amethyst, smoky-quartz and rock-crystal, opal and also kornerupine, danburite, scapolite and a beautiful ferriferous orthoclase.

Rock-crystal in remarkably fine specimens, rivalling those from any other source, have been found in Madagascar, which have been splendidly utilized in the ornamental arts. Fine examples of these crystals have been figured in Vol. I, plates 5 and 6. Large crystals have been utilized for several centuries for art objects and ornaments, and many of the artistic cups in our museums have been made from rock-crystal of Madagascar, which rivals that from Brazil in this respect. It is also employed for spheres, seals, boxes, perfume phials and for the pendants of chandeliers (Vol. II, p. 112).

The upright stones, called *vatomitsangana* (literally "standing-stone"), or *vatolshy* ("male-stones") in the Androy district of Madagascar (Vol. II, p. 169, Plate 18, opp. p. 166), are granite or gneissic monoliths erected in memory of a relative whose remains do not rest in the tomb of his ancestors. They are sometimes used as altars before which the natives offer prayer, and they anoint the sides of the stones with grease and place quartz pebbles on the summit. In size they vary from an average of two meters (6½ feet) to five meters (nearly 17 feet) in height, with a width of 50 or 60 centimeters (20 to 24 inches) and a thickness of from 25 to 30 centimeters (10 to 12 inches).

Danburite has been found in the pegmatites of Maharitra and in the eluvions of Imalo, in crystals sufficiently transparent to warrant cutting. They make a gem of madeira-yellow of various intensities, possessing properties closely similar to those of the topaz. Professor Lacroix believes some of them have been already sold under that name; he secured from Maharitra a stone weighing over five carats, and in a lot of minerals from Anjanabonoina he came across two fragments of danburite of a magnificent golden-yellow. One of these has been cut and furnished a gem weighing about 13 carats (Vol. II, p. 103).

The ferriferous orthoclase of Madagascar is sometimes of a magnificent golden yellow and occurs in crystals weighing up to 100 grains; it furnishes cut

stones of several grams, which make a very fine effect. The low degree of hardness does not permit the use of these for jewels in constant use, but nevertheless the stone can be utilized by jewelers. Perfectly clear crystals of fine color have sold for from 75 to 500 francs the kilogram (Vol. II, pp. 102, 103).

The transparent variety of kornerupine (prismatine) was found among some minerals gathered twenty kilometers east of Itrongay. It was in clear, isolated fragments of a deep olive-green, some of them four centimeters long, and was probably derived from a pegmatite rather than a gneiss. They furnish very beautiful cut stones. The polychroism is evident beneath a certain depth, and the tint varies a little according to the direction given to the table. The largest of several weighed 21 carats. The smallest stones, of a clear green, recall certain varieties of beryl and tourmaline (Vol. I, page 396; Vol. II, p. 102).

Professor Lacroix notes that among the cut tourmalines from Madagascar he has remarked the following colors (Vol. II, pp. 93, 94):

Red (rubellite): Magnificent stones varying from blood-red to vinous-red, sometimes with a violet tinge. Certain of them resemble rubies at Antandrokomby, etc.

Pink: Numerous varieties more or less pale; especially vinous-pink, salmon-pink, peach-blow color, recalling the tint of the beryls from the same region and also the burnt topaz. These are the predominant types at Maharitra.

Amethyst violet: At Anjanabonoina.

Golden-yellow to orange: These are the richest in manganese and the densest and most characteristic of Madagascar. Found, above all, at Tsilaizina.

Brown: Dark brown at Tsilaizina; coffee-colored and warm-browns at Anjanabonoina.

Grayish-brown, or smoky: Maharitra, Anjanabonoina.

Olive-green: Only furnish stones of inferior value. Maharitra, Anjanabonoina; much resemble the Brazilian.

Pale green: At Vohitrakanga, a variety, the olive hue of which recalls that of korneropine and some beryls.

Grass-green: A great range of shades, especially apple-green and grass-green, recalling some of the tourmalines from Maine. At Anjanabonoina, Maharitra. At Ankitsikitsika are some crystals half green and half red.

Blue: The indicolite variety is the most frequent. Maharitra. When very dark blue they have little commercial value.

Colorless: Madagascar furnishes probably the greatest number of fine, clear, colorless tourmalines, but they are rare. Maharitra, Anjanabonoina.

The statistics from 1897 to 1921 show that Madagascar yielded quite an amount of gold in that period, the total production being 42,129.95 kilos (1,354,579 ounces). For the past ten years or more there has been a steady falling off, from a maximum of 3,696.87 kilos (118,858 ounces) in 1909 to only 456.24 kilos (14,668 ounces) in 1921. The total value of this gold product was $27,989,147 for the twenty-five years, an average of over a million per year.

Graphite in considerable quantity has been mined on the island (Vol. II, pp. 148–155), and the exports have been quite important. The deposits occur in a great many localities; indeed, wherever there are gneisses, more or less graphite is to be found. The amount obtained varied much in the several years, reaching a maximum of 35,000 tons in 1917 and falling to about 4,000 tons in 1920. In 1917 the material brought 1,200 francs a ton in Marseilles.

Of the uraniferous minerals from which radium can be extracted, Madagascar furnishes a number (Vol. II, p. 132), for example, fergusonite, euxenite, samarskite, blomstrandite and three minerals special to the island, namely, betafite, samiresite and ampangabeite. There are also deposits of autonite and uranocircite. Of these the minerals which are economically important are betafite and euxenite, the former being much the most exploited; the largest deposit is that of Ambatofotsy (Vol. I, p. 386). Certain of these betafites have been worth as much as 15,000 francs a metric ton. These ores are sometimes sold according to the radium content, the unity being one milligram per ton, the value of this unit ranging from 100 to 200 francs.

The fourth section of the work is devoted to the lithology (or petrography) of the island, and Professor Lacroix states that the classification used is that which he has set forth during the past few years in his lectures at the Muséum d'Histoire Naturelle. He briefly summarizes it as follows:

> The eruptive rocks are considered, not only from the viewpoint of their mineralogical composition and their structure, as in the classification of Fouqué and Michel-Levy, but account is taken of the relative quantities of their constituent minerals, and also of their chemical composition, this latter point being especially considered in the present work.
>
> The rocks are divided into five great classes, based upon the nature of their white minerals (quartz, feldspars, feldspathoides). The first two comprise the rocks rich in quartz; the third class those rocks whose essential white elements are feldspars; the fourth is constituted by rocks in which the feldspars are accompanied by a notable quantity of feldspathoids (nephelines, leucitics), and, finally, the fifth class is reserved to the little group in which the sole white element is a feldspathoid. These divisions correspond to very important chemical properties, the excess of silica above the quantity necessary to enable the aluminum, joined with the requisite quantity of oxides, to form feldspars in the first two groups; the complete or approximate saturation of this silica in the third group, and its lack in the last two classes.

A very interesting part of the section "Lithology" is that devoted to comparison of the sodo-lithic peg-

matites of Madagascar with those of other countries (Vol. II, pp. 334–362). This embraces a careful description of these pegmatites in New England and in California, the greater part of the deposits having been studied in 1888 and in 1913 (pp. 334–346); in the last-named year Professor Lacroix was actively engaged in completing the great collection of American gems so generously donated to the Muséum d'Histoire Naturelle in Paris by J. Pierpont Morgan. He was accompanied on several of his excursions by the writer of the present notice and by Mr. Howe. He notes the striking resemblances between the pegmatites of California and those of Madagascar, the association in both regions of lithia tourmalines, notably of rubellite, caesium beryls, kunzite and spessartite, and the existence of native bismuth, of maganocolumbite. On the other hand, mineralogical differences must be noted.

The special attention here given by Professor Lacroix to these analogous formations in the United States is well worthy of remark in view of the fact that in but too many mineralogical handbooks composed by Europeans rather scant notice is taken of the United States.

Within the restricted limits of the present review we can only indicate the chief divisions of the section Lithography in Volume II, as follows:

FIRST DIVISION, INTRUSIVE ROCKS

Chap. I. Quartzite Rocks, pp. 229–243.
Chap. II. Pegmatites, pp. 244–376.
Chap. III. Syenites and Nephelinic Syenites, pp. 377–397.
Chap. IV. Rocks with Plagioclase, pp. 398–438.
Chap. V. Deformations and Transformations of the Eruptive Rocks, pp. 439–455.
Chap. VI. Contact Phenomena of the Eruptive Rocks, pp. 456–472.

SECOND DIVISION, CRYSTALLINE SCHISTS

Chap. I. Gneisses and Micaschists, pp. 479–522.
Chap. II. Quartzites, pp. 523–539.
Chap. III. Essentially Magnesian Rocks, pp. 540–545.
Chap. IV. Essentially Calcareous Rocks, pp. 546–574.
Chap. V. Exclusively Ferriferous or Aluminous Rocks, pp. 575–578.

THIRD DIVISION, INTRUSIVE POST-LIASSIC ROCKS

Chap. I. Quartzite Rocks, pp. 579–604.
Chap. II. Syenites and Nephelinic Syenites, pp. 605–622.
Chap. III. Syenito-Theralitic Series, pp. 623–643.
Chap. IV. Rocks with Feldspathoids without Feldspar, pp. 643–648.
Chap. V. Plagioclasites, pp. 649–655.
Chap. VI. Contact Phenomena of the Intrusive Post-Liassic Rocks, pp. 656–666.

The third and concluding volume[1] of Professor Lacroix's great work has been received since the review of the first two volumes was in type. This comprises the following petrographic sections: Post-liassic Volcanic Rocks (pp. 2–66); Sedimentary Rocks (pp. 67–91); Alteration of Rocks (pp. 92–149); Sketch of the Leading Lithological Characteristics of the Island (pp. 151–224). This is succeeded by a division devoted to a comparison of certain eruptive regions with those of Madagascar (pp. 227–294), and in the following brief section (pp. 295–334) the writer has grouped, in alphabetical arrangement and as an appendix, a series of mineralogical items which did not reach him until the earlier volumes were in press. The volume then concludes with a Bibliography (pp. 335–349), and an extensive Geographical Index of about 70 pages, succeeded by a Geological, Lithological and Mineralogical Index (pp. 421–431) and 4 pages of Errata. This truly monumental work is destined to remain an authority for a very long time.

GEORGE F. KUNZ
NEW YORK

SPECIAL ARTICLES

THE GENESIS OF NORMAL AND ABNORMAL CARDIAC RHYTHM

THE story of the development of the modern ideas concerning the cause of the heart beat constitutes an interesting chapter in medical history. Haller,[1] in 1757, was apparently the first to conceive that the rhythm of the heart was dependent upon the blood flowing through it. To quote:

> Qui hos experimentorum nostrorum eventus pensitaverit, is quidem non dubitabit nobiscum pronunciare, causam quae cor in motum ciet, omnino sanguinem venosum esse. Nam enata ea causa cor movetur, subtracta quiescit, diminuta motus cordis languet, aucta motus intenditur.
>
> Id si verum est, si porro cordis admotum major, quam aliorum musculorum, promtitudo est, si praeterea cordi perpetuus, dum vivimus sanguis advenit, non mirum est, perpetuum cordis motum esse.

Subsequently, in the early nineteenth century, arose the argument as to the neurogenic or myogenic origin of the beat with the evidence then considered to be in favor of the former. The work of Gaskell,[2] in 1881–83, cleared much of the confusion and laid the foundation for subsequent work by pointing out the control

[1] Tome III. Lithologie, Appendice-Index Geographique; Paris, 1923, 437 pp.; 28 text figures, 8 plates, and a colored geological map, 4to.

[1] Haller, Elementa Physiologiae Corporis Humani., 1757, tome I, p. 493.

[2] Gaskell, *Journ. Physiol.*, 1883, *4*, 43.

of the rhythm by the "pacemaking" venous end of the heart. At about the same time Langendorff[3] pronounced the theory that the tissue found its stimulus in the products of its own metabolism, and this view was later adopted by Englemann.[4] Ringer,[5] in 1883, perfused the isolated heart with artificial inorganic solutions and with his work there began extensive researches along this line.

An adequate review is not within the scope of this note. Through the work of many observers the cardiac muscle has come to be regarded as an irritable, conducting, contractile tissue mass which normally responds rhythmically to a so-called "inner stimulus." These fundamental properties, and the "inner stimulus" as well, have been shown to depend upon the composition of the fluid bathing the muscle tissue. Particular importance has been attached to the chlorides of sodium, calcium and potassium. More recently the significance of the reaction of this fluid has been pointed out.

For several years we have been interested in developing an approach to the problem of the cardiac arrhythmias by way of the origin of the normal rhythm. We have studied the isolated, perfused hearts of cold-blooded animals and of dogs. These observations, together with a review of the literature, have led us to advance a conception of the genesis of the heart beat which seems to explain the normal rhythm as well as many of the irregularities. The theory is not entirely a new one. It consists, in part, of the application to the excitatory process in the heart muscle of the results of the study of this phenomenon in other irritable tissues.

Simply stated, our conception is as follows:

The cardiac rhythm is due to the rhythmic building up and discharge of a potential difference across a semi-permeable membrane. The rate of development and magnitude of this potential difference are dependent fundamentally upon the difference in hydrogen ion concentration within the cells of the cardiac tissue and in the fluid bathing them. The level of potential difference at which discharge takes place is determined by the permeability of the interposed membrane. This, in turn, is dependent upon the concentration of sodium, calcium and potassium salts an either side of that membrane.

The muscle cell is essentially made up of an aqueous solution of colloids, certain organic compounds and electrolytes. It is surrounded by tissue fluid of a similar composition but differing from it in the concentration of certain ions. Thus, the muscle cell contains more potassium and less sodium and calcium than the tissue fluid. The concentration of hydrogen ion appears to be greater within the muscle cell than without. This ion is being constantly set free in the cell metabolism. On the other hand, the reaction of the tissue fluid is more rigidly fixed by "buffer" salts.

At the interface between two such phases such substances from each as lower surface energy tend to concentrate. Hence colloids, proteins and lipoids form a surface film which comes to assume definite characteristics as the cell membrane. Space does not permit a detailed description of this membrane, but the studies of Loeb,[6] Osterhout[7] and others assign to it special properties of permeability. It seems established that the membrane is impermeable to colloids. As regards crystalloids the situation is complicated by the presence of compounds of electrolytes and colloids. In addition, the properties of the membrane are such that a more or less constant difference is maintained in the concentration of the inorganic ions within and without the cell. Moreover, the degree and type of semi-permeability appear to vary with the cell and to depend upon the concentration of sodium, calcium and potassium salts in the immediate vicinity.

Since the ionic concentration is not the same within and without the muscle cell a definite potential difference develops across the surface film in accordance with the formula:

$$E = \frac{RT}{F} \cdot LN \cdot \frac{C}{C_1}$$

where C_2 and C_1 represent the concentration of the diffusible ion in the more concentrated and the more dilute phases, respectively. The cell membrane is thus polarized with the outer surface positively charged. Inasmuch as the hydrogen ion is by far the most rapidly moving ion concerned and experimental evidence shows that the polarization of the membrane is not due to the other cations it is to be inferred that the degree of potential difference existing across the surface film is dependent upon the difference in the hydrogen ion concentration in the muscle cell and in the fluid bathing it.

In 1911 Lillie[8] elaborated the "membrane theory" in explanation of the excitatory process in nerve. This theory, originally suggested by Hermann* and Brunings,† has since been shown to be in accord with the experimental evidence in this regard not only in nerve but in other irritable tissues as well. It may reasonably be applied to cardiac muscle. According

[3] Langendorff, *Arch. f. Anat. & Physiol.*, 1884 (supp. vol.), p. 1.

[4] Englemann, *Arch. f. d. ges. Physiol.*, 1897, *65*, 109.

[5] Ringer, *Journ. Physiol.*, 1880–82, *3*, 380.

[6] Loeb, J., *Journ. Gen. Physiol.*, 1922, *5*, 225.

[7] Osterhout, *Journ. Gen. Physiol.*, 1922, *5*, 220.

[8] Lillie, R. S., *Am. J. Physiol.*, 1911, *28*, 197.

* Hermann, L., Handbuch der Physiol., 1879, II, 194.

† Brunings, W., Arch. f. d. ges. Physiol., 1903, C, 367.

to the "membrane theory," the process of excitation involves changes in the permeability of the cell membrane at the point of stimulation and simultaneous depolarization. Since the remainder of the cell surface is positively charged, a current will at once begin to flow towards the stimulated area; this point becomes electronegative to the rest of the cell surface. This constitutes the action current and its strength depends, obviously, upon the potential difference existing across the membrane at the time of stimulation.

Nernst,[9] considering the effect of electrical stimuli, brought forward the view that stimulation involved a critical increase in concentration of ions on either side of a semi-permeable membrane. In other words, if a certain potential difference were developed across a membrane in a certain time that very potential difference would cause changes in the membrane which would constitute stimulation. Upon this conception he showed that any current to stimulate must fulfill certain relations of intensity and duration, as expressed in the formula:

$$I\sqrt{T} = c$$

where I represents intensity and T duration of current, and c denotes the threshold of the tissue involved. With minor modifications this relation has been shown by Lucas[10] to hold over a wide range of tissues. Lapicque[11] has shown that this formula applies to the polarization of artificial membranes as well.

Lillie has developed the conception that the process of conduction depends upon the excitation of the adjacent area by the action current developed at the point of stimulation. The action current from each excited point causes excitation in its neighborhood and the process is thus propagated in a wave over the tissue. The distance over which the action current can fulfill the requirements of Nernst's formula and so produce stimulation is determined by the potential difference existing at the point of stimulation and by the permeability of the cell membrane. Both of these circumstances are dependent, as we have outlined, upon the relative ionic concentration within and without the cell.

The heart is made up of a mass of tissue similar in composition to the muscle cell described. It is our conception that, under optimum conditions, the difference in hydrogen ion concentration within this muscle mass and in the tissue fluid bathing it, and the proportion of sodium, calcium and potassium are such that a potential difference is built up at a characteristic rate. When this potential difference has reached a certain level changes are thereby produced in the cell membrane which allow a transfer of electricity and stimulation. Once so initiated the excitatory process is propagated over the heart as described above, the action current from each excited point stimulating adjacent areas. It is this wave of negative potential difference which is registered as the electrocardiogram. A most important corollary to such a conception is this: No fiber of cardiac tissue can conduct the excitatory process unless it is itself excited.

Abnormalities of rhythm may thus be due to either or both of two derangements in this scheme: (1) To a change in the development of the excitatory process, (2) to a variation in the mechanism of its conduction, or (3) to a combination of these conditions.

First to consider derangements of impulse formation. Lewis[12] has pointed out quantitative differences in function of the four types of cardiac tissue, nodal, auricular and ventricular muscle, and Purkinje fibers corresponding to differences in structure. These tissues may be regarded as differing in the properties of their limiting membranes and hence in the rate of development of potential difference and in the level at which discharge takes place. Each type of tissue possesses an inherent rhythm. Normally, as Gaskell conceived, the rhythm of the sino-auricular node is most rapid and hence governs the rhythm of the heart. It has been shown that if the sino-auricular rhythm is eliminated some lower rhythmic center takes over control. In terms of our theory the condition of the cell membrane is such in the node that a potential difference is there built up more rapidly, or that discharge takes place at a lower level. Conversely, the same takes place at a relatively much higher level in the ventricular muscle and the inherent rhythm of the ventricle is much slower.

Alteration in the process of impulse formation may be produced either by alteration in the permeability of the interposed cell membrane through a change in the relative concentration of sodium, calcium or potassium, or by a change in the potential difference across the membrane. Our studies have recently been confined to alterations in the hydrogen ion concentration.

It is apparent that as the hydrogen ion concentration of the perfusate is increased the amount of the diffusible ion in the more dilute phase is raised. In other words, the potential difference across the cell membrane is diminished. Theoretically, such a reduced potential difference requires longer to effect stimulation. A priori, therefore, an increase in the hydrogen ion concentration of the fluid bathing the cardic tissue should slow the rhythm of the islolated

[9] Nernst, *Ztschr. f. Elektrochem.*, 1904, p. 665.

[10] Lucas, K., *Journ. Physiol.*, 1908, *37*, 459.

[11] Lapicque, *Compt. rend. d. l. Soc. d. Biol.*, 1907, *63*, 37.

[12] Lewis, *Quart. Journ. Med.*, 1921, *14*, 339.

heart; and it does so consistently. Conversely, an increase in alkalinity, by increasing the potential difference across the cell membrane, should cause a more rapid rate. All our records show that this is also the case.

With the heart in situ the vagus and accelerator nerves may be considered as operating upon the permeability of the cell membrane. The vagus, by decreasing permeability, slows the rate while the accelerator increases the rate of discharge by increasing the permeability. In this connection the work of Howell[13] showing the allied effects of the vagus and potassium is significant.

In experiments with the perfused heart it is possible to control only the hydrogen ion concentration in the fluid bathing the tissue of the heart as a whole. In pathological conditions, however, many other possibilities arise as regard an increase in the hydrogen ion concentration within the cell. The heart is a unique organ in that it is dependent upon itself for its own circulation. The conception is not a new one that with cardiac failure the myocardium suffers for want of a sufficient circulation. Under such circumstances, or even in the absence of clinical evidence of failure of the systemic circulation, local areas of deficiency in the intrinsic myocardial blood supply may conceivably arise. Such local failure of circulation must result in insufficient oxygen supply for the proper oxidation of the lactic acid formed in that area, in short, in a local increase in the hydrogen ion concentration within the tissue. The conditions are thus fulfilled for the development and discharge of a potential difference locally, for the genesis of a so-called ectopic focus of rhythm. The duration and rate of the development of the excitatory process in this focus are determined by the degree of local oxygen deficiency and by the condition of the cardiac tissue as a whole. A minor disturbance may give rise to arrhythmic or rhythmic extrasystoles which may or may not interrupt the dominant rhythm. A more severe change may produce a paroxysm of rapid excitations which may for a time command the rhythm of the whole heart, as illustrated by the onset of ventricular tachycardia following ligation of a coronary artery.

Secondly, arrhythmias may be due to variations in the process of the propagation of the excitation wave. As we have pointed out, according to the "membrane" theory, the rate of propagation of the excitatory process is determined by the area over which the local action current is effective in producing stimulation. Furthermore, this distance is dependent upon the magnitude of the potential difference and the permeability of the membrane. An increase in the hydrogen ion concentration without the cell results in a diminution in the potential difference across the cell membrane and hence a reduction in the intensity of the action current. Such a condition must reduce in extent the area over which the action current from any excited point can produce stimulation. Thus, such a change in the perfusate should slow the rate of propagation of the excitatory process.

Experimental evidence is entirely in harmony with this conception. The prolongation of conduction time in hearts perfused with acid perfusates has been noted by many observers. We have many records to show this. Heart block has been produced in animals by asphyxia and with narcotics. Clinically it is not unusual, in cases of heart failure, to meet with evidence of delayed conduction which disappears with the return of more normal circulation or upon the administration of oxygen.

Finally, more complex abnormalities of rhythm may involve changes both in the development of the excitatory process and in its propagation. If we suppose a local circulatory change giving rise to an ectopic focus of impulse formation, and, in addition, diffuse or local changes in conduction we have those conditions which, through the work of Mines[14] and of Garrey,[15] have been shown to be at the basis of the circus movement involved in flutter and fibrillation.

To summarize briefly: We have outlined a conception of the genesis of the cardiac rhythm as based upon the rhythmic development and discharge of potential difference across a semi-permeable cell membrane. We have described this potential difference as due to the difference in the hydrogen ion concentration within and without the cell, and its discharge as regulated by sodium, calcium and potassium through their effect upon the cell membrane. We have pointed out that local areas of circulatory deficiency in the myocardium may give rise to ectopic foci of impulse formation, and that diffuse changes in conduction may result from an increase in the hydrogen ion concentration of the perfusate. That gaps exist in the chain of evidence we are well aware. We hope, however, that we may have shown it possible to consider the cardiac arrhythmias as no more mystical than the normal rhythm and to offer an explanation common to both.

This communication is in the nature of a preliminary note. A complete account of our work will appear in an early publication elsewhere.

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[13] Howell, *Am. J. Physiol.*, 1905–6, *15*, 280.

[14] Mines, *Journ. Physiol.*, 1913, *46*, 349.

[15] Garrey, *Am. J. Physiol.*, 1914, *33*, 397.